

## Air Quality, Climate Change and Energy

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### Glossary

**Absorption** The uptake of molecules, ions or energy

**Acid rain** The deposition of acidic components in rain, snow, fog, dew, or other forms of water-based precipitation that have harmful effects on vegetation, water bodies, living organisms, soils, buildings and other external structures.

**Adaptation** Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected effects from major changes such as climate change. Examples of adaptation are raising river dikes and levees or substituting more temperature-resistant plant stocks for sensitive ones.

**Adsorption** The binding of molecules, ions or particles to a surface

**Aerobic** In the presence of air or oxygen

**Afforestation** Planting of new forests on lands that historically have not contained forests for at least 50 years

**Air quality** The condition of the air as it is expressed in terms of the concentration of pollutants relative to established baseline values (such as standards set by the Environmental Protection Agency). Air quality generally connotes some measure of the relative purity of the air.

**Allotrope** A substance consisting of only one type of atom that has a different structural and molecular configuration and physical properties than another form of that element in the same physical state.

**Alveoli** Tiny, thin-walled, capillary-rich sacs in the lungs that are the final branchings of the respiratory tree and act as the primary gas exchange units of the lungs.

**Ammonia** An odorous gas containing one nitrogen and three hydrogen atoms. Ammonia can also contribute to the formation of fine particulate matter. Ammonia is generated naturally by the decomposition of proteins or commercially by chemical processes.

**Anaerobic** In the absence of air or oxygen

**Anaerobic digestion** A process whereby microorganisms break down biodegradable material in the absence of oxygen

**Anthropogenic** Resulting from the influence of human beings on nature

**Atmospheric change** Variations in the characteristics of gases and other constituents in the air. These can be both natural and human-caused.

**Biofuel** A solid, liquid or gaseous fuel consisting of or derived from recently-dead biological material, most commonly plants or animal wastes. Biofuel is different from fossil fuel, which is derived from long-dead plants and animals.

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- Biomass** 1) the total mass of living or recently dead organic material in a given system  
2) living and recently dead biological material that can be used as a source of fuel or energy
- BTU** A British Thermal Unit (BTU) is the amount of heat energy needed to raise the temperature of one pound of water by one degree F. This is the standard measurement used to state the amount of energy that a fuel has as well as the amount of output of any heat generating device.
- Calorie** A unit of energy defined as the amount of energy required to raise one gram of water one degree Celsius
- Carbon cycle** The circulation of carbon atoms throughout the environment including the atmosphere, organisms, water, and the earth. Carbon is an essential element for life. The carbon cycle is useful for demonstrating the interrelationships between all natural resources.
- Carbon dioxide (CO<sub>2</sub>)** A naturally occurring compound that is integral for life functions on earth, found in gaseous form at earth surface temperatures. CO<sub>2</sub> is produced by all animals, plants, fungi and microorganisms during respiration and is used by plants during photosynthesis. Carbon dioxide is also generated as a natural by-product of the decomposition of organic matter and the combustion of fossil fuels or vegetative matter, among other chemical processes. Inorganic carbon dioxide is expelled during volcanic eruptions and geothermal processes producing geysers and hot springs. Carbon dioxide is an important greenhouse gas and is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance.
- Carbon footprint** A phrase for a measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide
- Carbon sequestration** The removal from the atmosphere and secure storage of carbon dioxide in oceans, forests, soils, or geologic materials through physical, biological processes such as photosynthesis, or man-made processes such as deep injection
- Carbon trading** A market-based mechanism for helping mitigate the increase in atmospheric carbon dioxide (CO<sub>2</sub>). It allows CO<sub>2</sub> emitters to offset these emissions by purchasing "credits" from individuals or organizations that sequester CO<sub>2</sub> or reduce CO<sub>2</sub> or other greenhouse gas emissions.
- Chemical energy** The energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together and can be released when the bonds are broken during chemical reactions.
- Chlorofluorocarbons (CFCs)** A family of chemical compounds developed back in the 1930's as safe, non-toxic, non-flammable alternative to dangerous substances like ammonia for purposes of refrigeration and spray can propellants. CFCs contain fluorine atoms, carbon atoms and chlorine atoms. Very little chlorine exists naturally in the atmosphere, but CFCs are an excellent way of introducing chlorine into the ozone layer. The ultraviolet radiation at this altitude breaks down CFCs, freeing the chlorine. Under the proper conditions, this chlorine has the potential to destroy large amounts of ozone. This has indeed been observed, especially over Antarctica. As a consequence, levels of genetically harmful ultraviolet

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radiation have increased. CFCs have a lifetime in the atmosphere of about 20 to 100 years, and consequently one free chlorine atom from a CFC molecule can do a lot of damage, destroying ozone molecules for a long time.

**Chlorosis** The yellowing of leaf tissue due to a lack of chlorophyll

**Climate** The statistically relevant aspects of the atmosphere-hydrosphere-land surface system that varies over periods of time ranging from months to thousands or millions of years. The classical period for averaging climatic variables as defined by the World Meteorological Organization is 30 years. Climate also describes the longer term statistical averages and measures of variability associated with daily weather.

**Climate change** Any systematic shift in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer. This can include changes to both averages of these elements as well as measures of variability and extremes. These changes can be caused by natural external forcings, such as changes in solar emission or slow changes in the earth's orbital elements; by natural internal processes of the climate system; or by human activities (anthropogenic forcings).

**Combustion** A series of complex chemical reactions between a fuel and oxygen leading to the production of heat or heat and light; burning

**Condensation** The physical process whereby vapor becomes a liquid or solid. In air quality terms, this can cause the formation of particulate matter from gases.

**Condensed distillers solubles (CDS)** The product obtained after the removal of ethanol by distillation from the yeast fermentation of a grain or a grain mixture by condensing the thin stillage fraction to a semi-solid

**Convection currents** Currents caused by the expansion of a liquid, solid or gas as its temperature rises

**Criteria pollutant** A pollutant determined to be hazardous to human health and regulated under EPA's National Ambient Air Quality Standards. The 1970 amendments to the Clean Air Act require EPA to describe the health and welfare impacts of a pollutant as the "criteria" for inclusion in the regulatory regime. Ozone and Particulate Matter are both criteria pollutants.

**Denitrification** The biological reduction of nitrate to nitrogen gas by denitrifying bacteria, usually in anaerobic conditions in soils and manures. The denitrification process is a part of the nitrogen cycle. Inefficiencies in the several steps of the denitrification process may also produce air emissions of NO<sub>x</sub> and nitrous oxide.

**Deposition** Atmospheric deposition is the result of airborne chemical compounds settling onto the land or water surface. These chemical compounds can be deposited onto water and land surfaces through both wet and dry deposition mechanisms. Wet deposition occurs through the absorption of compounds by rain as it falls, while dry deposition is the direct adsorption of compounds to water or land surfaces.

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**Direct energy** In agricultural systems, direct energy is the power that is used directly in growing a crop. It includes diesel, propane, gasoline, natural gas, electricity and other power sources used directly to run tractors and other vehicles, and to power lights, pumps, fans, motors and heating, cooling and drying systems on the farm.

**Direct Particulate Matter (PM)** Particles emitted in particle form (liquid or solid) that become entrained into the atmosphere (such as dust from wind erosion and field operations; smoke from fires; and droplets from chemical drift).

**Distillers dried grains with solubles (DDGS)** The product obtained after the removal of ethanol by distillation from the yeast fermentation of a grain or grain mixture by condensing and drying at least ¾ of the solids by the methods employed in the grain distilling industry

**Electrical energy** The energy associated with the flow of electrons

**Electromagnetic (EM) radiation** A self-propagating wave in space or through transparent matter. EM radiation has an electric and magnetic field component which oscillate in phase perpendicular to each other and to the direction of energy propagation. Electromagnetic radiation is classified into types according to the frequency of the wave. These types include (in order of increasing frequency): radio waves, microwaves, terahertz radiation, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. Of these, radio waves have the longest wavelengths and Gamma rays have the shortest. A small window of frequencies, called visible spectrum or light, is sensed by the eye of various organisms, with variations of the limits of this narrow spectrum. Light is sometimes used in a broader sense, referring to EM radiation.

**Embedded energy** Used synonymously with *indirect energy* in agricultural systems. It is the energy required to mine, manufacture, package, and transport materials used to grow agricultural crops or to produce livestock.

**Energy** The capacity of a physical system to do work, i.e., to make things move, whether at the molecular level or at a larger scale

**Energy efficiency** A general term used to compare the relative amount of energy required to perform a given amount of work under similar systems

**Energy transformation** The conversion of one form of energy to another. Energy transformation always results in some heat loss.

**Enteric fermentation** A decomposition process in which carbohydrates (such as feed) are broken down by microorganisms into simple molecules in the digestive systems of animals. This process is also known as digestion in animals. Enteric fermentation often results in methane, a greenhouse gas.

**Entrain** To draw in and transport (as solid particles or gas) by the flow of a fluid or fluid-like material

**EPA** Environmental Protection Agency, an agency of the U.S. government

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**Eutrophication** A process where bodies of water, such as lakes, estuaries, or slow-moving streams, receive excess nutrients that stimulate excessive plant growth

**Feedback (climate)** The partial reversion of the effects of a process to its source or to a preceding stage. An interactive mechanism between climate processes which results from an initial process triggering changes in a second process that in turn influences the initial process. Positive feedback intensifies the original process and negative feedback reduces it.

**Fermentation** A biochemical process in which carbohydrates are converted to either an acid or an alcohol. Fermentation is used to produce ethanol for fuel.

**Forcing(s)** An agent that causes a change in a system, such as a climate system. A volcanic eruption is an example of an external forcing that can change the composition of the atmosphere.

**Fossil fuel** A non-renewable source of energy that originated from ancient plants and animals up to 300 million years ago

**Geothermal energy** Thermal energy derived from heat within the earth

**Glycerol** A colorless, odorless, viscous sugar alcohol widely used in pharmaceuticals. It forms the backbone of triglycerides, the main constituent of animal fats. Glycerol is a 10% byproduct of biodiesel

**Gross domestic product (GDP)** A measure of the size of the economy of a country. GDP is defined as the total market value of all final goods and services produced within a given country in a given period of time (usually a calendar year).

**Greenhouse effect** A process in which certain gases (typically referred to as greenhouse gases) in the atmosphere effectively absorb longwave infrared radiation from the earth and then re-emit some of it back to the earth's surface and warming it

**Greenhouse gas balance** The difference between emissions of greenhouse gases into the atmosphere and the removal of greenhouse gases from the atmosphere into other earth systems. Specifically for agriculture, the greenhouse gas balance would be the comparison of emissions of carbon dioxide, methane, nitrous oxide, and other GHGs to the sequestration of carbon dioxide through photosynthetic activity into soil and biomass carbon.

**Greenhouse gases (GHGs)** Gases in the atmosphere that absorb and re-emit longwave (typically infrared) radiation from the earth (trapping heat). There are three principal GHGs of concern for agriculture: carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>).

**Holistic** Emphasizing the importance of the interdependent relationship between components (such as natural resources) by analyzing and understanding the functioning of the whole system, rather than the properties of the individual parts

**Hydroelectric energy** Electric energy produced by transforming the mechanical energy of moving water through a turbine to a generator

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**Hydronic** A ventilation system using heated or cooled water pumped through a building

**Indirect energy** The energy required to produce, package and transport materials to where they are used. In agriculture, nitrogen fertilizers are a significant source of indirect energy. The term is often used synonymously with *embedded energy*.

**Indirect Particulate Matter (PM)** Particles formed via processes in the atmosphere (such as condensation or chemical reactions of other gases).

**Isoprene** A volatile organic compound emitted naturally by many tree species. It is also an ozone precursor. The amount of isoprene produced depends on leaf mass, leaf area, light, and leaf temperature.

**Joule** A unit of energy that measures heat, electricity and mechanical work. One joule is the work done, or energy expended, by a force of one newton moving one meter in the direction of the force.

**Kinetic energy** The energy of motion, observable as the movement of an object, particle, or set of particles. Any object in motion is using kinetic energy: a person walking, a moving vehicle, a crumb falling from a table, and a charged particle in an electric field are all examples of kinetic energy at work.

**Lifecycle analysis** An assessment and tabulation of the environmental impacts of a product from its manufacture to final disposal including factors such as raw materials required in its manufacture, any pollution caused by its use and how it is disposed of. This process helps illustrate the environmental impact of a product and what can be done to reduce that impact.

**Mechanical energy** The energy of motion that is used to perform work.

**Metabolization** The sum of all the physical and chemical processes by which living organisms grow and function. Also known as metabolism, it includes the processes that break down substances to yield energy and processes that build up other substances necessary for life.

**Methane (CH<sub>4</sub>)** The principal component of natural gas and is associated with all hydrocarbon fuels. It is an important greenhouse gas with a global warming potential approximately 23 times higher than CO<sub>2</sub>. Methane emissions are generated by the decomposition or conversion of carbon compounds in the absence of oxygen (i.e., anaerobic conditions), such as in landfills, peat bogs, the intestines (especially of ruminants) or in an anaerobic lagoon or digester.

**Micro hydro** A small hydroelectric power plant producing less than 100 kilowatts of power.

**Mitigation** Technological change and substitutions that reduce resource inputs and emissions per unit of output. In a climate change context, mitigation means implementing policies to reduce greenhouse gas emissions and enhance sequestration.

**Necrosis** The death of living cells or tissues

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**Nitrate ( $\text{NO}_3$ )** A natural constituent of plants and is formed when nitrogen combines with oxygenated water. Nitrate is also a reactive atmospheric trace gas that photolyzes rapidly in the presence of sunlight. Nitrate is also a component of particulate ammonium-nitrate.

**Nitrification** The biological oxidation of ammonia to nitrate by nitrifying bacteria in aerobic conditions in soils and manures. The nitrification process is a part of the nitrogen cycle.

**Nitrogen cycle** The circulation of nitrogen atoms through the environment including the atmosphere, organisms, and the soil landscape. The nitrogen cycle demonstrates the interrelationships between all natural resources.

**Nitrogen oxides ( $\text{NO}_x$ )** NO plus  $\text{NO}_2$ .  $\text{NO}_x$  plays a role in the formation of ozone and particulate matter in the atmosphere. It is known as a precursor gas for both ozone and fine particulate matter.  $\text{NO}_x$  is generated either as a product of combustion (nitrogen in the fuel or air combines with oxygen in the air under combustion temperatures) or as an intermediate product in the denitrification cycle in soils and manures.

**Nitrous oxide ( $\text{N}_2\text{O}$ )** A greenhouse gas that has approximately 310 times more global warming potential than  $\text{CO}_2$ . Nitrous oxide is generated as an intermediate product in the nitrification and denitrification processes in soils and manures.

**Non-attainment** A designation by the EPA that one or more criteria pollutants in an area persistently exceed National Ambient Air Quality Standards, or that the area contributes to ambient air quality in a nearby area that fails to meet standards. This area is referred to as a Non-attainment Area.

**Non-renewable energy** An energy source that cannot be quickly regenerated and can thus be “used up”

**Nuclear energy** Energy stored in the nucleus of an atom. Nuclear energy can be released when the nuclei of atoms are either split or fused.

**Odor** The smell or scent of something. Odor is usually associated with the sensation that results when olfactory receptors in the nose are stimulated by particular chemicals in gaseous form.

**Odorous sulfur compounds** A group of sulfur-containing compounds (including hydrogen sulfide, mercaptans, and others) that have distinctive odors. Hydrogen sulfide odor is sometimes described as smelling like rotten eggs.

**Ozone** A molecule consisting of three oxygen atoms. It is found naturally in the upper atmosphere, where it filters potentially damaging ultraviolet light from reaching the Earth's surface. Ground-level ozone typically is a result of human activity, and is an air pollutant with harmful effects on the respiratory systems of animals and humans. It is not directly released into the atmosphere but is instead formed from the chemical reactions involving its precursor gases,  $\text{NO}_x$  and volatile organic compounds, in the presence of sunlight.

**Particulate matter (PM)** A complex mixture of solid particles or liquid droplets that are suspended in the air. These can enter the air directly (dust is an example), or be formed in the atmosphere



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through condensation or chemical reactions of certain pollutants, such as nitrogen oxides, ammonia, and volatile organic compounds. Particulate matter is of concern because it can be hazardous to health. It can degrade visibility and can deposit on surfaces, such as structures, soils, and water bodies. Particulate matter with aerodynamic diameter less than or equal to 2.5 micrometers (clay-size) is known as PM<sub>2.5</sub>, and similarly, PM with aerodynamic diameter less than or equal to 10 micrometers is known as PM<sub>10</sub>.

**Passive solar** Energy technologies designed to utilize energy from the sun directly, without mechanical transformation. Passive solar designs utilize placement, aspect and shading to optimize solar energy capture.

**Petroleum** Crude oil that is found naturally in sedimentary rocks and consists mainly of hydrocarbons. Petroleum is refined to form a variety of commercially important products, including gasoline and diesel. These petroleum-derived products are sometimes also referred to as petroleum.

**Photovoltaic cells** Devices that convert solar energy directly into electricity

**Potential energy** The energy an object has because of its position, rather than its motion. An object held in a person's hand has potential energy, which turns to kinetic energy — the energy of motion — when the person releases the object and it drops to the ground. Chemical bonds, such as those in diesel fuel contain potential energy that is released as kinetic energy when the bonds are broken during combustion.

**Power** The rate at which work can be (or is) done)

**Precursor** A substance from which another substance is formed, such as by a chemical reaction. For example, NO<sub>x</sub> and volatile organic compounds (VOCs) react in the presence of sunlight to form ozone; therefore, NO<sub>x</sub> and VOCs are ozone precursors.

**Radiant energy** The energy of oscillating electromagnetic waves, including radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays and gamma rays

**Small hydro** A hydroelectric power plant producing less than 10 Megawatts of power

**Smog** Air pollution, with or without the presence of fog, which typically gives the atmosphere a brownish appearance. It can be created by the photochemical interactions of atmospheric chemicals, including nitrogen oxides and hydrocarbons, primarily products of combustion. Ozone is also a significant contributor to smog, although ozone itself is nearly colorless.

**Solar energy** Energy derived from the sun. Solar energy technologies include passive solar, solar thermal and photovoltaic.

**Solar thermal** Energy technologies designed to convert sunlight into heat

**Stillage** The residue left after distillation of ethanol from a fermented mash

**Stomata** Tiny openings or pores in the epidermis (outer skin) of a plant used for gas exchange between the plant and the surrounding atmosphere.



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**SWAPA + H** Soil, Water, Air, Plants, and Animals, plus Humans.

**Terpenes** A class of volatile organic compounds emitted naturally by many plant species, in particular conifers. They are also particulate matter precursors.

**Thermal energy** The kind of energy that is related to or caused by heat

**Thermodynamics** The branch of physics and chemistry that deals with the transfer of energy and how energy causes movement

**Turbine** A device that converts the flow of a fluid (such as air, water or steam) into mechanical motion for generating electricity

**Urea ( $\text{CO}(\text{NH}_2)_2$ )** An organic chemical compound which essentially is the waste produced when the body metabolizes protein. Excess nitrogen can be excreted from animals in the form of urea.

**Volatile Organic Compound (VOC)** Gases arising from carbon-containing compounds. Many VOCs contribute to the formation of ozone and particulate matter in the atmosphere. VOCs are generated as intermediate products in the decomposition, combustion, or conversion of carbon compounds.

**Volatilization** The conversion of a chemical substance from a liquid or solid state to a gaseous or vapor state by the application of heat, by reducing pressure, or by a combination of these processes. Also known as vaporization.

**Watt** Named for James Watt, an International System (SI) unit of power equal to 1 joule per second

**Watt-hr** A unit of energy equivalent to one watt of power expended in one hour. Electricity use is usually measured in kilowatt hours, or 1000 watt-hours

**Weather** The immediate state of the atmosphere, mainly with respect to its effects upon life and human activities. Consists of short-term (minutes to daily) variations in atmospheric characteristics, such as temperature, humidity, sunlight, wind and visibility.

**Wind energy** Energy derived from moving air. Kinetic wind energy can be converted to mechanical or electrical energy by use of a rotating wind turbine.

**Work** The transfer of energy. The act of causing something to move.